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POLYCHLORINATED BIPHENYLS IN THE ONTARIO ENVIRONMENT

July, 1976

Ministry
of the
Environment

Ontario

The Honourable
George A. Kerr, Q.C.,
Minister

Everett Biggs,
Deputy Minister

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POLYCHLORINATED BIPHENYLS
IN THE
ONTARIO ENVIRONMENT

REPORT OF THE MINISTRY OF THE

ENVIRONMENT PCB COMMITTEE

July, 1976

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PREFACE

At the direction of Mr. K. H. Sharpe, Assistant Deputy Minister, Environmental Assessment and Planning Division, and Mr. J. R. Barr, Assistant Deputy Minister, Regional Operations Division, The PCB Committee was established with the following terms of reference:

1. To co-ordinate Ministry of the Environment investigations, data collection and information dissemination on PCBs;
2. To maintain liaison with other Provincial and Federal government agencies and industry groups involved in this matter and to make recommendations for co-ordination with Ministry programmes;
3. To recommend to management approaches to the investigation, monitoring and control of PCBs in the Ontario environment;
4. To serve as a contact point on the matter of PCBs, which is available to the Ministry to deal with control problems etc., and to answer questions from the media and the general public.

The purpose of this report is to summarize the recommendations of the Committee pertinent to these terms of reference and to provide background information in support of these recommendations.

SUMMARY OF RECOMMENDATIONS

1. The primary emphasis of the Provincial programme with respect to PCB in the environment should be directed towards the identification, investigation and control of sources of discharge. In this context, the following course of action is recommended:

   a) The co-operation of municipal authorities be sought in the investigation and control of sources of PCB discharge in municipal sewerage systems. In this regard, Metropolitan Toronto, City of Hamilton, City of Windsor, and the City of London would appear to be areas of prime interest;

   b) The notification and education of existing and former users of PCB of the environmental hazards and of the need for absolute control of losses;

   c) The development of procedures for the collection of waste PCB liquid and solid scrap and the transmittal of these wastes to approved disposal sites;

   d) The co-operation and assistance of the electrical industry be solicited in the control of losses of PCB from the manufacture, distribution, use and ultimate disposal of electrical equipment containing PCB;

   e) The on-going programme of identification and examination of airborne PCB emissions by The Air Resources Branch should be continued.

2. Air quality criteria, water quality criteria and effluent quality objectives for PCB should be developed in co-operation with Federal and Provincial environmental and health authorities.

3. Guidelines should be developed by the Ministry for the control of losses from manufacturing operations where PCBs are used and for the control of losses from the use of electrical equipment containing PCBs.

4. Monitoring programmes should be established which will utilize existing resources within various government agencies to best advantage and identify trends in the emission and transport of PCB throughout the environment.

INTRODUCTION

Polychlorinated biphenyls (PCBs) have been used for a wide variety of purposes since 1929. They were originally regarded as stable non-hazardous compounds and their widespread use has resulted in discharge to the environment.

The acute toxicity of PCB to humans was demonstrated by the accidental contamination of rice oil by PCB heat exchange fluid in Japan in 1968. The so-called Yusho disease which resulted from this contamination has been well documented and reported (Kuratsune etal. 1972). Toxicological studies of laboratory animals have indicated that PCBs may cause enlargement of the liver and other liver defects, decreased vitamin A storage and impaired steroid metabolism (Kimbrough 1974).

In 1971, because of the mounting body of evidence of the accumulation of PCBs in the environment and their potential hazard to fish and wildlife and to man, sales of PCBs were restricted by Monsanto, the only North American manufacturer, to uses in electrical equipment which were believed to be non-dispersive and which would not allow discharge to the environment. This resulted in a 50% decline in the sales of PCBs. However, many potential sources of discharge remain from past and present uses of PCB.

There is also a mounting body of evidence of the widespread distribution of PCB in the global environment. The Great Lakes Region gives evidence of being one of the most heavily contaminated areas in North America. PCBs in Great Lakes fish, particularly recently stocked coho salmon, are a major concern in that they exhibit levels of contamination up to ten times higher than that established by Fisheries and Marine Service of Environment Canada as being acceptable for commercial sale. This places in jeopardy the Great Lakes fisheries stocking programme which has been undertaken by the various Provincial, State and Federal agencies bordering the Great Lakes.

Recent findings showed that rats fed a commercial PCB mixture Arochlor 1260 over 21 months developed liver cancers (Kimbrough 1975) and that normal reproduction of rhesus monkeys was impaired at dietary levels as low as 2.5 ug/g (Allen 1975). Of particular concern are the implications of these findings to human health and the potential hazard associated with the consumption of fish.

PCBs IN THE ONTARIO ENVIRONMENT

Considerable data has been assembled on the extent of PCB contamination of the environment in Ontario. This is considered in some detail in Appendix I.

In general, the distribution of PCB contamination in water, sediments, air, rainfall, fish and wildlife correspond to the density of urban and industrial development. Contamination of fish in the Great Lakes is highest in Lake Ontario and Lake Erie and lowest in Lake Superior. Large salmonid fish and eels show the highest levels of contamination.

The limited assessment of PCB in air and the data from rainfall and from surface waters with no history of direct PCB contamination suggest that airborne transport may be a significant factor in the distribution of PCB throughout the environment.

Levels of PCB in sediments show distribution patterns corresponding to density of municipal and industrial development. Municipal sewage effluents may be significant in this regard since most sewage effluents contain traces of PCB. However, the quantity of PCB discharged from these sources is very small.

The disposal of municipal sewage sludge, either by land application or by incineration, may contribute to the contamination of soils and to airborne contamination respectively.

It is evident that the extent of contamination of the Ontario environment is widespread. Further monitoring of the environment, while necessary from the standpoint of the protection of the general public from the effects of PCB contamination, will not add much to the general body of knowledge or contribute greatly to the solution of the problem. What is essential where feasible, is that further inputs to the environment be eliminated.

PCB DISCHARGES

In general, PCB discharges to the environment show no consistent pattern of source, mode of entry or quantity. There are many small diffuse sources. Appendix II deals with this topic in detail.

It is evident that there are numerous minor sources of discharge. Because of the quantities involved, the greatest potential for loss is within the electrical industry via losses during the manufacture, sale, distribution, use and ultimate disposal of electrical equipment containing PCB.

Municipal sewage treatment plants, electrical equipment manufacturers, industries using PCB as heat transfer or hydraulic fluids and paper recycling plants have all been identified as sources of discharge. However, the quantities involved are unlikely to be sufficient to account for the estimated quantities in sediments and waters in the Ontario environment. Nevertheless, quantities in, for example, municipal effluents may be sufficient to contaminate 100 million kg/year of fish.

It appears that current levels in the Ontario environment may be the result of the accumulation of discharges over many years.

CONTROL STRATEGIES

In a general sense the strategies that are available to the Province to achieve control of PCBs are very much related to the approach to be taken by the Government of Canada under The Environmental Contaminants Act and under The Fisheries Act. The Province is represented on the Federal PCB Task Force, which has been assigned to make recommendations for regulation under The Environmental Contaminants Act. The primary concern of such regulations are the dangers posed to man, and other living things by PCBs in the environment. These dangers arise from the inherent toxicity of PCBs and the exposure of man and other living things to PCBs. Since the toxicity of PCB cannot be controlled, emphasis must be placed on controls that will reduce exposure. Exposure in man is a function of intake, principally via the diet, and atmospheric exposure; while exposure in other living things is by a variety of means but is ultimately reflected by the level of PCB in their tissues. In practice, reducing exposure to PCBs means reducing the level of PCBs in organisms, sediments etc., which will indirectly lead to reduced intake of PCBs by man.

Residues of PCB in the environment can be reduced by:

(i) restricting the purposes for which PCBs may be used,

(ii) restricting losses into the environment from permitted uses,

(iii) restricting the proportion of environmentally persistent PCBs in material lost into the environment.

Of these three choices, only item (ii), restriction of losses, is appropriate to Provincial jurisdiction. Items (i) and (iii) are consistent with the controls envisaged under The Environmental Contaminants Act. Nevertheless, it is necessary to consider the options available to the Government of Canada under item (i) and (iii) in order to assess their impact on Provincial control on losses. Taking each in turn:

1) Restricting the purposes for which PCBs may be used may lead to:

a) total prohibition

b) restriction of the uses of PCBs to those that offer the greatest benefits and the least risk to the environment.

The total prohibition of PCBs would result in a gradual decline in levels of PCB in the environment and involve the Province in the monitoring and control of losses from existing and past usage. This appears to have been the choice in Japan, although even here some importation of PCB is necessary to maintain existing electrical equipment. It remains to be seen whether Japan can successfully sustain such a ban and whether tangible and immediate benefits to the environment can be realized by this approach, (and at what cost in terms of reduced fire and safety protection in electrical equipment).

The restriction of PCB usage to those applications that offer the greatest benefits compared to the risk of PCB loss is essentially the basis of the selective sales policy implemented by Monsanto in 1972. Again, this approach would involve the Province in the control and monitoring of PCB losses and levels in the environment.

2) The restriction of losses into the environment from permitted uses covers the conventional anti-pollution field via control of wastewater effluents, airborne emissions and disposal of solid wastes. The generalized approaches that may be used to achieve such control are summarized below:

Industrial wastewaters:

Plants utilizing PCBs for permitted uses should be monitored and any identified route of PCB entry into these wastewaters should be eliminated. It is not clear that setting a concentration standard for PCBs in industrial wastewater is a meaningful exercise in terms of reducing discharge of PCBs into the environment. It is very clear that the highest attainable standards of plant housekeeping must be maintained to prevent any entry of PCBs into wastewaters.

Stack-gas emissions:

Data is lacking on this route of loss, and it is not known if losses from manufacturing plants are at all significant. There is some evidence of high levels of PCB in air near incinerators and it is suspected that this could be a significant source of PCBs. Whether modification to raise the operating temperatures of waste incinerators will partially eliminate the problem is not known. Certainly, disposal of manufacturing wastes known to contain PCBs should not be permitted to incinerators other than those known to achieve destruction of PCB. Specially designed units are capable of destroying PCBs by incineration if the PCBs are fed to the unit in an oil feed and sufficient residence time and a combustion temperature in excess of $1000^{\circ}C$ are provided. Preliminary tests suggest that liquid chlorinated organic wastes can be destroyed in cement kilns, and simultaneously serve a valuable purpose in the manufacture of special grades of Portland cement.

Disposal of solid wastes:

Little can be done about the unidentified PCBs in the products already marketed that will inevitably be disposed of in the future. However, a few products containing PCBs from past manufacture are still in use in identifiable situations and their disposal could be subject to new regulations.

If uses of PCBs are legally restricted it is expected that so-called industrial "solid wastes" containing PCBs would be limited to:

used transformers,
used power capacitors,
wastes from electrical equipment manufacturers.

All these could readily be segregated for processing in ways known to recover or destroy PCBs.

3) Reducing exposure by restricting the proportion of environmentally persistent PCBs in material lost into the environment was the basis of the revision of the Arochlor product line by Monsanto in 1972, in which Arochlor 1260 and Arochlor 1242 were replaced by Arochlor 1254 and Arochlor 1016 respectively. These replacements contain less of the higher chlorine content, more persistent biphenyls. It should be noted that these changes may have resulted in the introduction of less persistent but more acutely toxic lower chlorine content PCBs.

This approach is unlikely to have a significant impact on Provincial controls except in the context of what is controlled and monitored in discharges.

The fact remains that current electrical applications of PCBs cannot totally eliminate the higher chlorine content isomers since these have the desirable fire retardent and electrical properties.

ALTERNATIVES TO PCB IN ELECTRICAL APPLICATIONS

Because of their long standing application as electrical insulating fluids in transformers and capacitors, PCBs have become the yardstick by which all other candidates are measured. Normal commercial pressures have failed over the past 47 years to find superior replacements for PCBs in these applications. Environmental concerns have revived interest on the part of chemical manufacturers to develop commercially acceptable alternatives which do not cause environmental problems. Non-PCB alternatives for capacitor fluids include:

a) Mineral oils - these require larger capacitors and are less reliable and are not flame retardent;

b) Modified synthetic hydrocarbons - these can replace PCBs in existing equipment but are still flammable;

c) Phthallate esters - these are electrically acceptable alternatives but are toxic and flammable;

d) Substituted aromatics - these have limited application to high voltage power factor capacitors, (17% of current U.S. production);

e) Plastic film paper replacement capacitors are feasible but have not yet proven reliable and are more expensive.

Dow Chemical Incorporated have developed a capacitor fluid XFS-4169L which has electrical properties comparable to Arochlor 1016. Extensive environmental testing has been done on this product. It is some twenty times less toxic (LC50 15 mg/l to fathead minnows) than Arochlor 1016; it is biodegradable; it has relatively low toxicity to mammals and has low bioconcentration factors. It remains to be seen whether its inferior fire resistance is a significant obstacle to its acceptance as an alternative to Arochlor 1016 by the electrical industry.

Monsanto also have under development alternative capacitor fluids which have the desirable electrical properties of Arochlor 1016 and are biodegradable and have low toxicity. Again, the fire retardent properties are not as good as Arochlor 1016.

Prodelec A.S., France, have an alkylated dichlorbiphenyl which is comparable to Arochlor 1016 but is less toxic and rapidly excreted in mammals relative to tetrachloro and pentachloro biphenyls.

Dow Corning Limited have also indicated that silicone replacement fluids are available for transformers and capacitor applications. These products are based on dimethyl silicone. Silicones have been used as insulating fluids in military applications for 20 years and have been used in Japanese railroads for the past 5 years. Silicones are less flammable than mineral oils but are more flammable than PCBs. They have very low toxicity and have a long history of usage as food additives.

All of these alternative products are at various stages of testing to determine full scale electrical performance and environmental effects.

In summary, it appears that alternative materials to PCB for insulating fluids are available, but, in the absence of specific regulation on PCB sales, their usage will depend on their acceptance by the electrical industry. There are many factors involved in their acceptance by the electrical industry, particularly from the standpoint of fire safety.

Consequently, it is difficult for this Ministry to have impact on these deliberations except to emphasize the concern for the environmental effects of PCBs. In some areas the usage of PCB in electrical equipment is specified by industrial safety regulations, for example in underground mine workings, and changes in these regulations can only be made after very serious consideration.

In any event, Monsanto have recently announced that the company intends to eventually phase out the production of polychlorinated biphenyls. While no timetable for this phase-out has been presented, Monsanto indicate that as soon as acceptable alternatives are developed by itself or its competitors Monsanto will voluntarily shut down its PCB manufacturing facility.

MONITORING REQUIREMENTS

There are major gaps in the knowledge of the extent and nature of PCB contamination in the Ontario environment. It is essential that future monitoring programs fill these gaps where they may have impact on public health.

In this regard, priority should be assigned to the assessment of levels of PCB in recreational lakes and in potable waters. At the same time, monitoring in support of pollution abatement programmes are essential to the goal of eliminating further inputs of PCB to the environment.

Existing and proposed monitoring programs to achieve these goals are described in detail in Appendix III.

CONCLUSIONS AND RECOMMENDATIONS

PCBs are widely distributed in the Ontario environment. They are present in air, water, sediments and soils. Elevated levels in the vicinity of urban and industrial centres point to these centres being the primary points of PCB discharge. All municipal sewerage systems in Ontario are likely to be sources of PCB discharge. Sources of PCB losses within most of these municipal sewerage systems are essentially unknown.

Airborne transport, rainfall and particulate fallout are potentially significant in terms of quantitative inputs of PCB into the aquatic environment and on to land.

Levels of PCB in fish are of immediate concern, particularly from the standpoint of consumption of fish caught by sports fishermen. Commercial fish catches in the Great Lakes seldom exceed the guideline of 2 ppm maximum PCB in the edible portion that was recently established by The Fisheries and Marine Service of Environment Canada.

Sports fish, particularly salmonoid species that were introduced into the Great Lakes by various State and Provincial agencies show evidence of the highest levels of contamination.

There is some evidence of a comparable situation in inland recreational waters in Ontario but this has not yet been firmly established.

The mechanisms by which fish accumulate PCB in their tissues are not well defined. Some experimental data suggests that this occurs primarily by direct intake from the water via ingestion through the skin, gills and gastrointestinal tract. Feeding studies confirm that uptake can also occur via dietary intake. Concentration factors for PCB uptake from water ranging from 6300 to 71,400 have been reported. It is evident from this that there is a need to establish a desirable water quality criteria for PCB to ensure that levels in fish do not exceed 2 ppm.

Similarly, in spite of the fact that there is currently no evidence of PCB contamination of potable water supplies, there is a need to establish a drinking water standard for PCB in order to protect public health.

In both of these cases, there is a corresponding need to develop control procedures and technology to ensure that these water quality criteria and drinking water standards can be met.

The establishment of a comprehensive program for the monitoring, assessment and control of PCBs in the Ontario environment should be a primary objective in the design of Ministry programs and should entail the optimum utilization of laboratory and other resources.

Towards this end, any commitment of Ministry resources to co-operative programs for the assessment of PCBs in the environment or in fish and wildlife should only be made to the extent that they do not hinder any anticipated Ministry programs of PCB source assessment. In particular, laboratory resources development should be geared to provide adequate capacity for analysis and investigation for both Ministry and inter-Ministry co-operative programs.

It is recommended that the co-operation and assistance of municipal authorities be sought in the identification and elimination of sources of discharge of PCBs within municipal sewerage systems. It would appear logical that the investigation and sample collection within municipal sewerage systems be undertaken by the municipalities while the Ministry provides technical assistance in sampling and conducts the analyses. Because of the large number of municipalities involved it is recommended that, initially, the municipal sewerage systems which have been already identified as significant sources of PCB discharge be investigated. These are: Metropolitan Toronto; City of Hamilton; City of Windsor; and the City of London.

It is recommended that the assessment of airborne emissions of PCB by the Ministry, together with the co-operative programs with The Environmental Protection Service, Ontario Region, that have been described in Appendix III be continued.

In concert with programs to abate PCB discharges, facilities must be made available to dispose of PCB wastes. At the present time only the facility at Model City, New York, operated by Chemtrol Disposal Services is suitable for disposal of PCB contaminated solids and the incineration of liquids.

Preliminary results of the study on the burning of PCB and other liquid chlorinated hydrocarbons in the cement kiln at St. Lawrence Cement Company Limited, in Mississauga, suggest that this is an acceptable method of utilization and disposal of such liquids.

The problem of solid waste disposal remains. It is recommended that the Ministry work towards the establishment of a solid waste disposal facility that can handle PCBs and other hazardous or persistent materials.

Much of the PCB contamination currently identified is suspected to be of historical origin, from uses of PCB which have been curtailed. It is, therefore, recommended that all former users of PCB in dispersive applications such as heat transfer and hydraulic fluids be investigated and that these former users be notified of the environmental hazard of PCB and the need for absolute control of losses.

Continued co-operation should be maintained with Environment Canada in the development of regulations under The Environmental Contaminants Act with the Province taking a strong role in the implementation of such regulations.

APPENDIX I

PCBs IN THE ONTARIO ENVIRONMENT

PCBs in Water

Analysis of surface waters in Ontario indicates that PCBs are present in concentrations from non-detectable up to 100 parts per trillion.

Tables I and II are indicative of the quantities of PCB in natural waters draining into Lake Huron and Lake Superior.

TABLE I

PCB in Canadian tributaries to Lake Huron in Kg/year 1973

Location	PCB in Kg/yr
St. Mary's River	
East Davignon Creek	0.312
Georgian Bay	
McCurry Lake	0.021
Wanapetti River	16.6
Severn River	22.5
Nottawasaga	11.6
Bighead River	4.71
Orchard Creek	0.21
Sydenham River	2.06
Pottawatami River	0.67

(From Working Group C, Land Source Inputs. Ministry of the Environment, Ontario)

TABLE II

PCB in Canadian tributaries to Lake Superior in Kg/year 1973

Location	PCB in Kg/yr
Kaministikqia River	0.075
McIntyre River	0.001
McVicar Bank	0.0003
Black Sturgeon River	0.40
Nipigon River	0.40
Jackpine River	0.0027
Steel River	0.047
Prairie River	0.013
Little Pic River	0.069
Pic River	0.30
Magpie River	0.30
Wawa Creek	0.0029
Michipicoten River	0.90
Old Woman River	0.022

(From Working Group C, Land Source Inputs. Ministry of the Environment, Ontario)

Data have also been gathered on levels of PCB in streams draining agricultural areas in Southern Ontario through a study undertaken on behalf of Task Group C (Canadian Section) International Reference Group on Great Lakes Pollution from Land Use Activities International Joint Commission (PLUARG). A summary of the PCB data and sources is contained in Table III.

TABLE III

PCB Concentrations in Agricultural Drainage

Watershed	Total Area (Square Miles)	No. Samples	PCB ppb Mean	PCB ppb Range
Big Creek	20	10	.17	.06-.44
North Creek	7.7	1	.07	-
Little Ausable	20.9	10	.21	.00-.53
Cauagagigul	8.0	18	.14	.00-.25
Middle Thames	10.6	8	.20	.00-.53
Teeswater	21.0	9	.14	.04-.36
Ganaraska	15.0	5	.19	.08-.27
Boyle Drain	14.4	9	.19	.10-.58
West Humber (Mono Mills)	-	7	.10	.00-.21
North Creek (Twenty Mile Creek)	13.0	11	.10	.00-.18
West Humber (Wildfield)	11.7	9	.16	.07-.24
Wilton Creek	7.2	11	.12	.00-.32

TABLE III (continued)

Watershed	Total Area (Square Miles)	No. Samples	PCB ppb Mean	PCB ppb Range
Hillman Creek	13.9	11	.21	.09-.38
Little Mill	10.9	8	.12	.05-.24
Little Jerry	12.0	1	.15	-
Special Study (Niagara Fruit Belt)	1.0	9	.09	.02-.16

It was the conclusion of this study that, because PCBs were found in the drainage from the various watersheds at consistently similar levels, crops, soils or farming activities were not factors in the levels of PCBs encountered. Also, there was no apparent association of PCBs with DDT or other pesticide usage. This points to the possibility of other factors such as atmospheric fall-out being a significant source of PCB in these drainage areas.

In a complementary study, rainfall samples were collected at some of these same watersheds by Dr. Marie Sanderson, University of Windsor, and analyzed in the Provincial Pesticide Residue Laboratory, Ontario Ministry of Agriculture and Food, Guelph. The data from these studies is summarized in Table IV.

TABLE IV

Residue of PCB in Rainfall, 1975

Watershed	Collection dates and PCB residues (ppb)		
	27 May -23 June	24 June -28 July	29 July -03 September
Big Creek, Essex	0.06	0.05	0.05
Little Ausable, Huron	0.04	0.05	0.10
Upper Canagagigue, Wellington	0.01	0.05	0.07
Middle Thames, Oxford	0.05	ND	0.10
Twenty Mile Creek Niagara N.	0.02	0.08	0.05
Hillman Creek, Essex	0.03	0.06	0.07

Other preliminary information from rain water samples indicates that PCBs are present at about 0.02 ppb based on four samples (three from Hamilton Harbour and one from Wisconsin (Report of the PCB Task Force) The implication from this preliminary work is that rain water is a very significant source of PCB to the aquatic environment, particularly to the Great Lakes.

PCB in Potable Waters

Examination of some potable waters from municipal water treatment plants in Ontario have been conducted for PCBs. These data are summarized below:

Location	Sample	*PCB ppb
Toronto R.C. Harris W.T.P.	Raw	N.D
	Treated	N.D
	Filtered	N.D
Brantford	Raw	N.D
	Treated	N.D
	Filtered	N.D
Cayuga	Raw	N.D
	Treated	N.D
	Filtered	N.D
Markham John St.	Raw	N.D
	Treated	N.D
Markham Don Mills	Raw Well 3	N.D
	Raw Well 2	
	Raw Well 1	
	Treated	N.D
	Household	

N.D - None detected

* - Unit of detectability for PCB is 0.01 ppb

In addition to these data, the following municipal water supplies have been analyzed and have no detectable PCB:

Amherstburg
Belleville W.T.P.
Bowmanville
Chatham
Dresden W.T.P.
Elgin W.S.S.
Goderich W.T.P.
Grand Bend
Guelph
Hawkesbury
Napanee
Niagara-on-the-Lake
Ottawa-Lemieux
  Carleton Reg. Brittania
Pembroke
Prescott
Sudbury
Thunder Bay
Lakeview W.T.P.
Union W.S.S.
Windsor

PCBs in Sediments

Patterns of distribution of PCBs in sediments appear to be related to sources of urban and industrial discharge. Levels of PCBs are low in Lake Superior and high in Lake Erie, particularly in the western basin. This reflects the distribution of industrial and urban inputs in these lakes. Similar patterns of distribution can be found in many other receiving streams in Ontario

Some of the areas that have been investigated include:

Hamilton Harbour

A 1972 survey of PCB in sediments in Hamilton Harbour by the Ministry of the Environment showed levels of 1,300 ppb in the canal region, 2000 to 3000 ppb in the region of the industrial waterfront and 10,000 ppb near the sewage treatment plant. These levels are the highest documented in Canada and confirm that this environment is one of the most polluted in North America.

Lake Erie

Figure 1 shows the concentration of PCB in samples of sediments from Lake Erie which have been analyzed by Dr. R. Frank and Dr. R. L. Thomas of The Provincial Pesticide Laboratory and CCIW respectively. The PCB situation is complicated in the western basin by scouring in the Detroit River. The main source of PCB to Lake Erie is from the Detroit and Manmee Rivers. The map also indicates that there are possible additional sources on the American side.

Upper Lakes

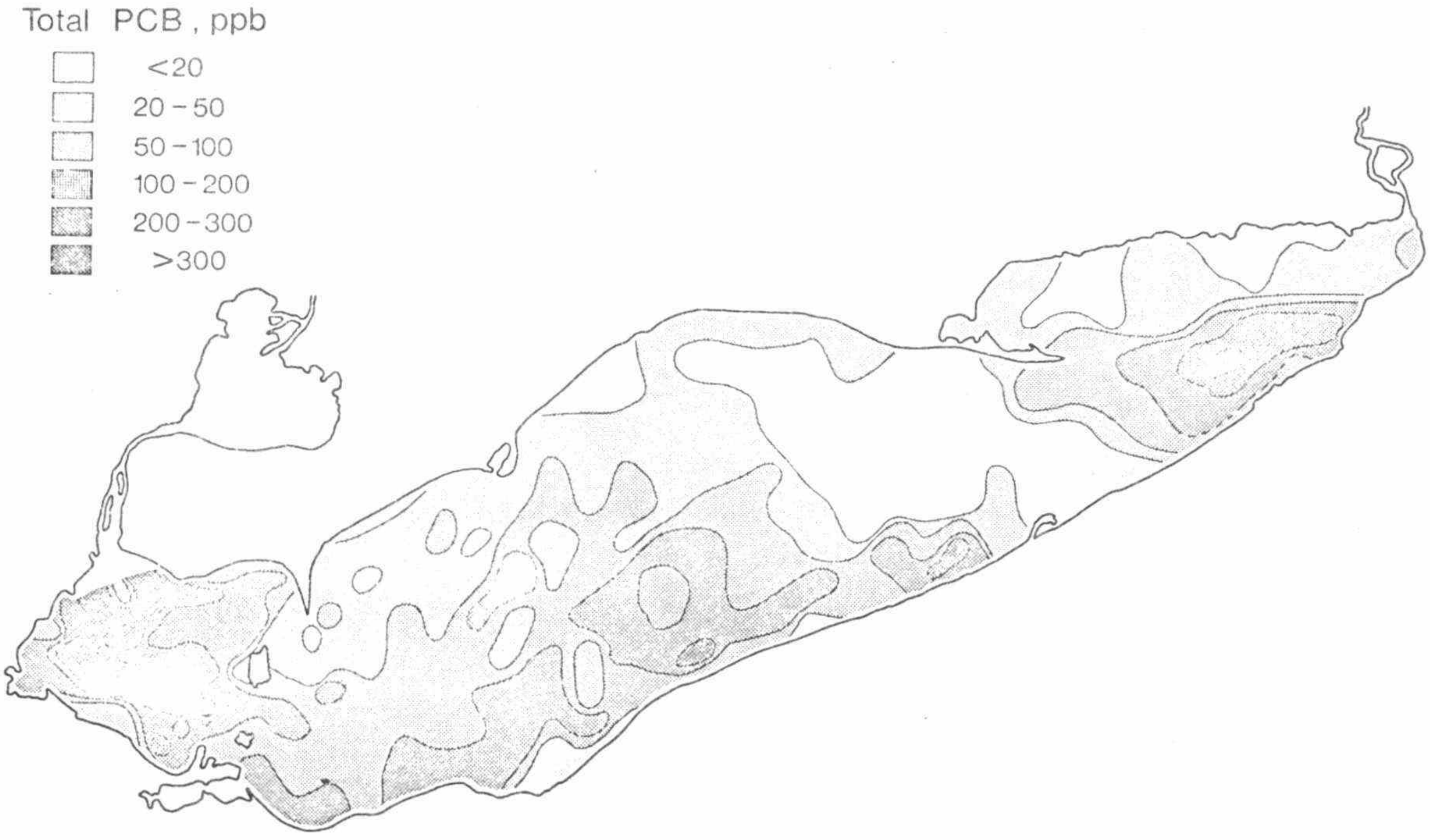
Thirty-four (34) sediment samples have been collected from Lake Huron (including Georgian Bay) and Lake Superior (Strachan unpublished CCIW report, 1975). In Lake Huron, PCBs were present at all the stations either at or below the level of quantification of 10 ppb. Samples around the periphery of the Lake were at trace levels whereas the two central samples contained 10 ppb. This would suggest a fairly rapid sorting of the PCB, probably associated with sorting and transport of the fine material. The sample from Saginaw Bay where large amounts of PCB have been discharged in the past contained only a trace.

In Georgian Bay the south eastern samples from around Collingwood, Midland and Parry Sound contained 20 ppb. In the two samples from the North Channel one contained 10 ppb, the other contained a trace.

In Lake Superior, the results indicated a large source of PCB at Marathon where the sample contained 1300 ppb. Resorting of this material probably resulted in the sample from the centre of the Lake containing 90 ppb. Other samples from the periphery of the Lake contained trace quantities up to 20 ppb.

There are no data available on levels of PCB in sediments in inland recreational lakes in Ontario.

DISTRIBUTION OF PCBs IN SEDIMENTS IN LAKE ERIE



PCBs in Fish

Fish intended for commercial sale have been analyzed for several years by the Fisheries Inspection Branch, Fisheries and Marine Services, Environment Canada. At the same time samples of some commercial fish catches in Ontario are collected by Ontario Ministry of Natural Resources and submitted to Ontario Ministry of the Environment for analysis. The Sports Fisheries Branch of the Ministry of Natural Resources has also collected samples of various fish species from recreational lakes. These fish have been submitted to Ministry of the Environment Laboratories and the Provincial Pesticide Residue Laboratory for PCB analysis.

Table V summarizes data on PCB residues in two fish species selected as indicators of contaminant levels in the affected waters by the Fisheries Inspection Branch.

TABLE V

PCB in Suckers and Yellow Pickerel in the St. Lawrence Great Lakes System in ppm in the edible portion

Location	Suckers	Yellow Pickerel
Great Lakes		
Lake Superior	-	0.37
Lake Huron, Georgian Bay	-	1.09
Lake Erie	1.65	1.16
Lake Ontario	1.20	2.02

TABLE V (continued)

Location	Suckers	Yellow Pickerel
St. Lawrence River		
Lac St. Francis	1.83	3.72
Lac St. Louis	0.98	1.19
Lac St. Pierre	-	1.03
Central Canada		
Lake Winnipeg	-	0.10
Manitoba small lakes	0.07	0.07
Saskatchewan small lakes	-	0.10
Alberta small lakes	-	0.10

The Yellow Pickerel data indicate that PCB levels in Lake Superior are the lowest within the Great Lakes system. The levels are much higher in Lakes Huron and Erie but are highest in Lake Ontario at approximately 2 ppm.

Within the St. Lawrence River very high values were found in Lac St. Frances, but values decrease in the lakes further downstream. The data from Central Canada probably reflect background contamination from atmospheric fallout. Major sources of contamination into the Great Lakes are indicated by these data.

Sports fish appear to exhibit the highest level of PCB contamination. This probably reflects the fact that such fish are usually predators and at the end of food chains and thus are the terminal receptor for contamination via food chain bioaccumulation. Also, there appears to be some association between the fat content of fish and PCB contamination. This is probably because PCBs are quite fat soluble. Furthermore, some studies have indicated that salmonoid fish accumulate PCB to a greater extent by direct ingestion from water than by dietary intake. Bioconcentration factors of 6300-71,400 and 12,400 have been reported for PCB accumulation in fish by direct contact and ingestion from water. Juvenile salmon exposed to 1 mg/l Arochlor 1254 solubilized by Corexit 7664 for 24 hours had a total body residue of 60 ug/g. (Zitco and Hutzinger).

Table V represents PCB residue data for coho salmon taken at the mouth of the Credit River in Lake Ontario in the Fall of 1975.

TABLE V

PCB ANALYSIS RESULTS FOR COHO SALMON TAKEN FROM THE CREDIT RIVER, FALL, 1975

Analyses were performed on edible fillets taken from each fish.

Weight of fish in kilos	Percent fat in edible tissue	PCB level in parts per million
4.3	19	22.5*
4.5	5	5.5*
1.6	18	22.5*
4.9	14	21.0*
4.3	5	4.9*
4.3	14	18.8*
4.4	12	13.0*
2.2	8	12.0*
5.0	4	4.0
2.3	3	3.8
5.2	4	6.3*
2.8	4	2.6
4.0	17	21.8*
4.9	3	4.2
4.5	7	8.3*
2.0	6	5.2*
4.4	12	18.4*
3.5	11	8.5*
4.2	5	16.0*
5.3	7	10.0*
2.5	2	2.7
4.2	15	11.3*
2.2	5	14.1*

TABLE V (continued)

Weight of fish in kilos	Percent fat in edible tissue	PCB level in parts per million
3.7	3	5.2*
2.6	11	12.4*
4.7	4	3.7
2.0	11	8.5*
4.2	7	4.4*
2.6	8	6.9*
4.7	2	2.5
5.2	3	3.1
6.3	2	2.9
5.3	2	2.1
4.9	4	3.9
6.3	7	6.8*
5.0	2	2.3
4.8	4	3.4
4.3	4	4.2
5.2	1	2.1
5.1	8	10.7*

* Far exceed the 2 ppm guideline

Analyses were performed on edible fillets taken from each fish.

PCB present resembled a mixture of Arochlors 1254 and Arochlors 1260 in the ratio 4:1.

A summary of the range of PCB in fish from various watersheds was prepared by The Water Resources Branch in November, 1975, in response to the announcement by Fisheries and Marine Services of Environment Canada of the new 2 ppm standard for PCB in the edible portion of fish for commercial sale. This summary is presented in Table VI.

TABLE VI

PCB's IN FISH

LAKE	YEAR	AREA	SPECIES	Number of Samples	% Distribution		
					<2 ppm	2-5 ppm	>5 ppm
Ontario	1971	Credit River	Coho Salmon	5	0	0	100
	1974	Credit River	Coho Salmon	7	0	0	100
	1974	Credit River	Brook Trout	6	100	0	0
	1974	Toronto Waterfront	Yellow Perch	6	100	0	0
	1974	" "	White Perch	4	0	75	25
	1974	" "	White Sucker	29	90	10	0
	1974	" "	Brown Bullhead	12	84	8	8
	1974	" "	Northern Pike	7	100	0	0
	1975	Credit River	Coho Salmon	42	0	45	55
Erie	1971	-	Yellow Perch	29	Average-	0.65 ppm	
	1971	-	White Bass	31	Average-	1.5 ppm	
	1972	-	Yellow Perch	60	100	0	0
	1972	-	White Bass	60	100	0	0
	1972	-	Smallmouth Bass	36	100	0	0
Huron	1973/74	Goderich	Trout	10	50	50	0
	1973/74	"	Sucker	10	100	0	0
	1973/74	"	Perch	10	100	0	0
	1973/74	Douglas Point	Trout	10	60	40	0
	1973/74	" "	Sucker	10	100	0	0
	1973/74	" "	Northern Pike	10	100	0	0
	1973/74	Owen Sound	Trout	10	100	0	0
	1973/74	" "	Sucker	10	100	0	0
	1973/74	" "	Perch	10	100	0	0

LAKE	YEAR	AREA	SPECIES	Number of Samples	% Distribution		
					< 2 ppm	2-5 ppm	> 5 ppm
Huron (cont'd)	1973/74	Thornbury	Trout	10	90	10	0
	1973/74	"	Sucker	10	100	0	0
	1973/74	"	Perch	10	100	0	0
	1973/74	Nottawasaga Bay	Trout	7	86	14	0
	1973/74	" "	Sucker	10	100	0	0
	1973/74	" "	Perch	9	100	0	0
	1973/74	" "	Walleye	3	100	0	0
	1973/74	Penetang-Midland	Perch	2	100	0	0
	1973/74	" "	Rock Bass	10	100	0	0
	1973/74	" "	Walleye	10	100	0	0
	1973/74	Spanish River	Sucker	10	100	0	0
	1973/74	" "	Perch	7	100	0	0
	1973/74	" "	Northern Pike	10	100	0	0
	1973/74	Serpent River	Sucker	9	100	0	0
	1973/74	" "	Perch	9	100	0	0
	1973/74	" "	Northern Pike	10	100	0	0
	1973/74	Lake George	Sucker	10	100	0	0
	1973/74	" "	Perch	4	100	0	0
	1973/74	" "	Northern Pike	10	100	0	0

LAKE	YEAR	AREA	SPECIES	Number of Samples	% Distribution <2 ppm	2-5 ppm	>5 ppm
Superior	1973/74	Batchawana Bay	Trout	9	100	0	0
	1973/74	" "	Whitefish	10	100	0	0
	1973/74	" "	Herring	10	100	0	0
	1973/74	Michipicoten Bay	Trout	10	100	0	0
	1973/74	"	Whitefish	10	100	0	0
	1973/74	"	Herring	10	100	0	0
	1973/74	Marathon	Trout	10	100	0	0
	1973/74	"	Whitefish	4	25	25	50
	1973/74	Jackfish Bay	Trout	10	100	0	0
	1973/74	" "	Whitefish	10	100	0	0
	1973/74	" "	Herring	10	100	0	0
	1973/74	Rossport Point	Trout	10	100	0	0
	1973/74	" "	Whitefish	10	100	0	0
	1973/74	" "	Menominee	10	100	0	0
	1973/74	Nipigon Bay	Trout	4	100	0	0
	1973/74	" "	Whitefish	10	90	10	0
	1973/74	" "	Herring	10	100	0	0
	1973/74	Black Bay	Trout	10	70	30	0
	1973/74	" "	Whitefish	10	100	0	0
	1973/74	" "	Herring	9	100	0	0
	1973/74	Thunder Bay	Trout	10	90	10	0
	1973/74	" "	Whitefish	10	100	0	0
	1973/74	" "	Herring	10	100	0	0

LAKE	YEAR	AREA	SPECIES	Number of Samples	% Distribution		
					<2 ppm	2-5 ppm	>5 ppm
Superior (cont'd)	1973/74	Pine Bay	Trout	10	100	0	0
	1973/74	" "	Whitefish	10	100	0	0
	1973/74	" "	Walleye	100	10	0	0

Data on fish from Lake Huron and Lake Simcoe which were analyzed by the Provincial Pesticide Residue Testing Laboratory in Guelph are summarized in Tables VII and VIII.

It is evident from these data that there is a marked association between fish size and fat content and PCB content. Also, it appears that salmonoid fish species such as trout and coho salmon are most affected.

TABLE VII

PCB in Lake Trout and Eggs from Lake Simcoe

(From Provincial Pesticide Residue Testing Laboratory analysis
of Ontario MNR samples)

Sample	Weight grams	Length cms	% Fat	PCB ppm
L. Trout M	2983	62.0	13.4	0.7
L. Trout M	3185	66.0	11.3	0.7
L. Trout M	2534	59.0	10.6	0.8
L. Trout F	3314	71.0	12.0	1.1
Eggs			4.56	0.4
L. Trout M	3440	62.0	11.5	0.8
L. Trout F	2013	56.0	4.87	0.3
Eggs			4.78	0.3
L. Trout M	3630	62.5	12.0	0.6
L. Trout F	3379	62.0	10.9	1.3
Eggs			3.71	0.3
L. Trout F	3598	57.0	9.96	0.6
Eggs			4.27	3.0
L. Trout M	2069	55.0	11.8	1.0
L. Trout M	3459	59.5	10.3	1.2
L. Trout F	2925	61.0	13.8	1.3
Eggs			5.82	0.4
L. Trout M	2622	61.5	13.7	0.9
L. Trout F	3568	67.5	8.54	1.1
Eggs			3.84	0.9
L. Trout F	3251	63.5	12.8	0.9
Eggs			6.05	0.4

TABLE VIII

PCB in Fish from Georgian Bay

(Task Force 'D' IJC by Provincial Pesticide Residue Laboratory)

	Weight grams	Length cms	% Fat	PCB ppm
Yellow Pickerel - South Bay Mouth	5218	70.0	1.92	0.4
" "	2099	58.0	3.12	0.3
" "	2180	59.5	2.89	0.6
" "	1617	53.5	3.85	0.8
" "	1037	44.5	2.31	0.5
" "	722	37.0	2.68	0.5
" "	2910	55.0	2.59	0.5
" "	3750	59.5	1.45	0.3
" "	3580	60.0	12.6	2.5
" "	2281	51.0	13.3	1.3
Small Mouth Bass - Georgian Bay	562	31.5	4.14	0.8
" "	320	26.5	2.60	0.5
" "	472	32.0	2.41	0.5
" "	385	26.0	3.22	0.6
" "	338	27.5	1.68	0.7
" "	313	26.0	4.45	0.4
" "	275	25.0	3.05	0.6
" "	317	26.0	3.07	0.3
" "	297	23.0	4.37	0.9
Large Mouth Bass "	83	16.5	0.82	1.3
Rock Bass "	185	20.0	0.95	0.5

PCB in Soils

There are few data available on levels of PCB in soils. What data are available are indicative of contamination via the disposal of sewage sludge.

Sewage sludge from industrial and municipal wastewater treatment plants is frequently contaminated with PCB. The problem of soil and crop contamination from disposal of this material was investigated by Agriculture Canada in 1972 and 1973. Sewage sludge samples were collected from Southern Ontario and analyzed for PCBs. Much of the sludge went to farmland as manure whilst the rest went to landfill. Samples of soil from some of the treated farmland were analyzed as were some of the crops. Table IX shows the levels of PCB in the sludges, Table X levels of PCB in soils treated with sludge and Table XI levels of PCB in crops from treated fields.

The ultimate fate of PCB disposed of in this way is uncertain. Presumably there will be some adsorption into soil particles and some will be leached into drainage water. Degradation by the soil microflora probably occurs in the soil. Volatilization, transportation, reprecipitation and photodegradation are other factors affecting the concentration of PCBs in the treated soils. A quantitative assessment of these phenomena in the field has not been attempted. If crops are found to take up high concentrations of PCBs, the practice of dispersing PCB sludges onto farmland may have to be re-evaluated. An alternative to this practice is to incinerate the dried sludge at a temperature and for a time sufficient to combust the PCBs.

TABLE IX

Concentration of PCB in Ontario sewage sludge in ppm dry matter.
1972 and 1973

Location	PCB	Type
Lake Huron Watershed		
Barrie	3.25	1254
Newmarket	0.57	1254
Bradford	2.87	1254
Aurora	1.81	1254
Lake St. Clair and St. Clair River Watershed		
Chatham	0.87	1254
Corunna	3.93	1254
Sarnia	7.72	1254
Wallaceburg	3.2	1254
Detroit River		
West Windsor	33	1254
Little River	1.18	1254
Amherstberg	2.98	1254
Lake Erie Watershed		
Kitchener	5.37	1254
Galt	1.45	1254
Guelph	5.46	1254
Leamington	0.18	1254
Cedar Springs (Hosp)	14.1	1254
Point Edward	1.58	1254
Brantford	3.08	1254
Stratford	4.17	1254

continued

TABLE IX (continued)

Location	PCB	Type
Lake Ontario Watershed		
Georgetown	5.37	1254
Richmond Hill	1.86	1254
Peterborough	6.79	1254
Welland	4.52	1254
Toronto (Humber)	49.45	1254
Stanford Niagara	1.76	1254
Port Weller	10.0	1254
Port Dalhousie	10.3	1254
Burlington (Drury)	9.2	1254
Burlington (Skyway)	21.0	1260
Hamilton	32.5	1254
Oakville (S.E.)	4.6	1254
Oakville (S.W.)	31.4	1254
Lakeview	12.2	1254
Clarkson	31.7	1260
North Toronto	1.55	1254
Whitby	11.6	1254
Ajax	1.76	1254
Pickering	2.92	1254
Bowmanville	11.1	1254
Oshawa	2.50	1254

TABLE X

Concentration of PCB in ppb in soils treated with sewage sludge from southern Ontario. 1972

Location	Source	Number of Applications	PCB	Type
Blair	Kitchener	1	5	1254
Galt R.R. #2	Kitchener	1	N.D.	-
Norval	Georgetown	1	10	1254
Norval	Georgetown	1	7	1254
Norval	Not known	-	N.D.	-
Georgetown	Georgetown	1	37	1254
Stratford	Stratford	Several	715	1254
Whitby	Whitby	1	N.D.	-
Ajax	Ajax	1	43	1260
Pickering	Pickering	6	150	1254
Bowmanville	Bowmanville	1	46	1254
Oshawa	Oshawa	1	N.D.	-
Vineland	Port Dalhousie	1	N.D.	-
Vineland	Port Dalhousie	1	N.D.	-
Toronto Int Airport	Stratford	1	120	1254
Halton City	Burlington	2	150	1260
Richmond Hill	Richmond Hill	several x/yr/5yr	N.D.	-
Aurora	Aurora	2-3	8	1254
Ottawa	Ottawa	1	43	1254
Guelph	Guelph	20-25 yrs	370	1260
Guelph	untreated	0	5	1254
Guelph	untreated	0	5	1254
Guelph	Guelph	1	47	1260
Guelph	Guelph	1	15	1254
Guelph	Guelph	1	23	1254
Barrie	Barrie	1	N.D.	-
Vespra	Unknown	1	N.D.	-

TABLE XI

Concentration of PCB in crops from fields treated with sewage sludge in ppb

Location	Source	Crop	PCB	Type
Galt	Kitchener	Potatoes	N.D.	-
Galt	Kitchener	Turnips	N.D.	-
Galt	Kitchener	Mangolds	N.D.	-
Norval	Georgetown	Corn	N.D.	-
Norval	untreated	Corn	N.D.	-
Norval	Georgetown	Tomatoes	N.D.	-
Norval	unknown	Corn	N.D.	-
Norval	Georgetown	Mixed grain	28	1254
Georgetown	Georgetown	Apples	N.D.	-
Guelph	Guelph	Corn	5	1254
Guelph	Guelph	Corn	95	1254
Elora	Guelph	Corn	30	1242

N.D. - None detected

(From CDA unpublished survey)

PCBs in Air

Summary of Work Completed by Air Resources Branch

Beginning with the 1970-71 and 1971-72 fiscal years, Dr. G. H. S. Thomas of the Ontario Research Foundation received grants under the Air Resources Branch Research Grant Program to develop sampling and analytical methods for the determination of polychlorinated biphenyls in ambient air. A report on the results of this work issued in October, 1972, (ORF 72-1) described the successful development of reliable sampling and analytical techniques and a few quantitative measurements at two sites. The ambient air concentration of PCB (as Arochlor 1254, Monsanto's commercial mixture) at a site near the Hamilton municipal incinerator ranged from 4 to 47 ng/m^3 (ug/1000m^3) and at a site on the ORF roof (non-urban, light industrial) from 0.8 to 8 ng/m^3.

These fragmentary results suggested that the disposal of PCB-containing materials by incineration might be a source of emissions to the atmosphere.

The sampling method (Millipore membrane and glass fibre filters followed by ethylene glycol-filled impingers) was designed to collect both particulate and vapour-phase PCB, so that the above concentrations refer to total PCB levels in air. The method was not refined enough to determine the particulate and vapour-phase PCB separately.

During 1973/74, Dr. Thomas obtained an ARB Research Grant to continue development of the experimental methods, to identify potential sources of PCB emissions to the atmosphere, to determine the relative amounts of particulate and vapour-phase PCB, and to carry out a brief literature search on potential PCB emission sources and the fate of the PCBs in the environment. Two reports on the results of this work were issued in August, 1975 (ORF 75-1 and 75-2).

Table 1 from the report ORF 75-1 (see Page 54) summarizes the PCB levels at three sites at Sheridan Park, Hamilton and Toronto (67 College Street) over the period April, 1974 to January, 1975. Particulate (Hi-Vol filter extract) and vapour-phase (impinger extract) PCB are reported separately. At Hamilton, particulate PCB ranged from 0.3 to 0.4 ng/m^3 and vapour-phase PCB ranged from 2 to 8 ng/m^3. At 67 College Street, Toronto, particulate PCB ranged from 0.3 to 3 ng/m^3 and vapour-phase PCB from 0.9 to 2.6 ng/m^3. The ratio of PCB in the vapour-phase to that in the particulate-phase ranged from 2 to 20 over various samples taken at the three sites on different days. It is clear from these data that PCBs are found predominantly in the vapour-phase and cannot be quantitated by extracting Hi-Vol filters (particulate) alone.

Professor F. W. Karasek of University of Waterloo has received ARB Research Grant funding during fiscal 1973/74, 1974/75, 1975/76 to carry out research on the development of techniques for the trace analysis of the organic fraction (cyclohexane or methanol extractable) of particulate sampled from ambient air. Hi-Vol filters from ARB stations at Welland and Simcoe have been submitted to Prof. Karasek's group who have been able to identify and quantitate many specific organic substances in the particulate matter, among them various PCBs. No systematic evaluation of quantitative PCB concentrations has been attempted or reported based on the work, but the capability exists to analyze qualitatively and quantitatively for particulate PCB.

Summary of Current Activities Within The Technology Development and Appraisal Section

The Special Studies and Programme Planning Unit is preparing a background report on PCBs in ambient air, relying in part on the ORF reports outlined above. This report will cover sampling and analytical methods, hazardous properties, control and abatement technology, emission sources, and measured ambient concentrations in Ontario and elsewhere. It will comprise evaluation of the current status of the PCB problem and recommendations for future action by Air Resources Branch.

The Technology and Process Evaluation Unit is currently carrying out discussions with major manufacturers of PCB-containing equipment to determine emissions, evaluate control measures and to study the possibilities of process improvement to reduce emissions. Five plants in Ontario use a vacuum-filling technique to fill high-voltage transformers and capacitors with various

PCB formulations. It is felt that significant emissions to the atmosphere occur from venting of vacuum pumps and from transfer processes. The five installations under observation are:

1) Canadian General Electric, Peterborough
2) Canadian General Electric, Guelph
3) Westinghouse Canada, London
4) Westinghouse Canada, Hamilton
5) Ferranti-Packard, St. Catharines

Summary of Activities Elsewhere

Dr. R. Frank, Ministry of Agriculture and Food, Pesticide Residue Testing Laboratory, Guelph, has published surveys of PCB concentrations in milk fat (butterfat) in Southern Ontario (Journal of Milk and Food Technology, Vol. 38, No. 2, pages 65-72, February, 1975). A copy of Table 7 from the above reference is appended on page 54. A suggestion is made in this article that measured PCB levels in counties in or near heavy industrial areas (Essex and Niagara Counties) are clearly greater than in more remote areas (Elgin, Middlesex, Oxford and Norfolk Counties). Levels for individual counties across Southern Ontario are within 50% of the mean value for the region, however, which suggests a relatively weak correlation with industrial activity and at least regional transport of PCB, perhaps through ambient air.

An article in Science (vol. 183, pages 516-518, 8 February, 1974) by Professors T. F. Bidleman and C. E. Olney of the University of Rhode Island also presents data on airborne PCB. A copy of Table 1 from that paper is appended on page 54. The PCB concentrations are comparable with those found by ORF in Ontario, ranging from a low of 0.3 ng/m^3 over Bermuda to a high of 9 ng/m^3 at Providence, Rhode Island. These researchers also found that the predominant fraction of airborne PCBs are in the vapour rather than particulate phase.

Similar results were reported by A. Sodergren (Nature 236, 395-7, 1972) and by G. R. Harvey and W. G. Steinhauser(Atmos. Environ. 8, 777-782, 1974).

Conclusions

The results of ambient air surveys in Ontario, elsewhere in North America, and on a global scale demonstrate that airborne PCBs are to be found in appreciable concentration in the atmosphere far from sources.

High PCB concentrations at the ORF sampling site near the Hamilton municipal incinerator are suggestive, but not conclusive, evidence that incineration may release PCBs from various materials into the atmosphere. PCBs are chemically very stable and will not be destroyed (oxidized) under the relatively mild conditions obtained in incinerators which have not been specially designed for the purpose. This problem requires further study.

Drs. Bidleman and Olney (op.cit.) calculate that the residence time of atmospheric PCB is about 40 days (at least several days to several weeks, depending upon the accuracy of measurements). This calculation is based on the observation that the atmosphere is the major source of PCB in the oceans by wet and dry deposition. Because of the long atmospheric residence time and the appreciable concentration of PCB in the atmosphere over Ontario, it is likely that wet and dry deposition of PCB from the atmosphere is a major source of these substances in soil and surface water in Ontario. In this context, it is imperative to identify emission sources of PCBs so that the necessity for control measures can be evaluated and so that an abatement strategy can be formulated on a rational basis.

It is clear that conventional Hi-volume sampler particulate samples cannot be used to quantitate PCBs, since the large majority of PCB is in the vapour-phase and since the vapour/particulate concentration ratio will vary depending upon proximity to an emission source, which may be very diffuse (such as a solid waste disposal area, etc.). Special techniques must be used to sample total (vapour plus particulate) PCB in order to determine accurate ambient air or source emission data.

The Technology Development and Appraisal Section has also been involved in co-ordinating the Ministry's contribution to an experimental waste chlorinated hydro-carbon incinerator project at the St. Lawrence Cement Company in Mississauga. The project has been sponsored principally by Environment Canada with additional contributions from this Ministry and the U.S. EPA. Phase III of this project concerned the burning of waste PCBs. Final tests and source test sample analyses are currently being completed. The final report is scheduled for July, 1976.

Table 1

COLLECTION of PCBs from AMBIENT AIR

G.H. THOMAS
ORF-75-1

Sample Date & location	Hi-Vol				Impingers	
	Volume air (m^3)	Weight Particulate(g)	PCB found* ($\mu g/g$)	PCB found* (ng/m^3)	Volume air (m^3)	PCB found* (ng/m^3)
(1974)						
ORF roof						
9/4 - 16/4	16,257	0.65	3.55	0.14	346	1.32
Hamilton Stn. 29026						
19/7 - 23/7	9,787	0.61	4.15	0.26	-	-
23/7 - 29/7	12,589	0.92	4.84	0.35	164	1.95
16/9 - 23/9	17,127	1.00	7.54	0.44	347	8.3
College Street						
16/10 - 23/10	16,842	0.53	13.59	0.43	305	2.27
23/10 - 30/10	16,093	1.75	5.64	0.61	295	1.89
30/10 - 31/10	2,426	0.27	27.60	3.07	-	-
30/10 - 5/11	-	-	-	-	264	2.43
31/10 - 5/11	7,340	0.34	9.1	0.42	-	-
5/11 - 11/11	-	-	-	-	264	1.92
8/11 - 11/11	7,829	0.63	4.33	0.35	-	-
11/11 - 15/11	9,216	0.60	7.68	0.50	179	2.22
15/11 - 22/11	16,230	0.96	6.10	0.36	309	2.63
22/11 - 29/11	16,557	0.85	5.94	0.30	317	1.15
29/11 - 6/12	15,659	0.80	7.10	0.36	306	1.48
6/12 - 13/12	14,925	0.92	6.40	0.40	305	0.92
13/12 - 23/12	9,737	0.50	9.96	0.51	424	1.57
23/12 - 31/12	17,943	0.65	10.49	0.38	311	1.27
(1975)						
7/1 - 17/1	20,064	0.90	9.23	0.41	268	1.20
17/1 - 29/1	23,316	1.10	10.55	0.48	322	1.98

* Quantitation of PCB is based on Aroclor 1254

Flow rates - through impingers =1 cu ft/min
through Hi-Vol =60 cu ft/min

TABLE 7. *Residues of industrial pollutants in milk fat of the southern region.*

County	Content in butterfat (ppm)				
	1970-1971	1973		1970-71	1973
	PCB	PCB	HCB	Ratio DDT/PCB	
Brant	0.14	0.11	0.011	1.39	0.83
Elgin	0.07	0.07	0.006	1.60	0.76
Essex	0.10	0.17	ND	0.80	0.21
Haldimand	0.12	0.14	ND	1.26	0.29
Kent	0.07	0.13	0.007	0.67	0.17
Lambton	0.08	0.13	0.008	0.71	0.10
Middlesex	0.06	0.09	0.008	1.40	0.36
Niagara	0.10	0.15	0.003	1.46	0.37
Norfolk	0.12	0.08	0.005	2.36	1.18
Oxford	0.03	0.09	0.009	3.37	0.67
Wentworth	0.15	0.10	0.011	1.05	0.70
Southern region	0.08	0.11	0.007	1.53	0.47
			Annual amount in milk supply (Kg)		
			PCB	PCB	HCB
Southern region			1.68	2.33	0.152

R. Frank, et al

J. Milk Food Technol 38, 65 (1975).

Table 1. Concentrations of chlorinated hydrocarbons in marine and continental air (the total retained by the glass-fiber filter and trapped on the polyurethane foam). Filter-retained values for the Bermuda samples were less than 2 percent and less than 5 percent of the total for PCB and DDT, respectively; —, not determined; U.R.I., University of Rhode Island.

Sample	Collection dates (1973)	Location*	Volume of air (m^3)	PCB† (ng/m^3)	p,p'-DDT (ng/m^3)	o,p'-DDT (ng/m^3)	Chlordane‡ (ng/m^3)
1	2/12–2/13	Bermuda	1070	0.59	0.013	0.014	< 0.005
2	2/13–2/14	Bermuda	1320	0.30	0.012	0.012	< 0.005
3	2/15–2/16	Bermuda	918	0.65	—	—	—
4	2/16–2/18	Bermuda	1950	0.62	—	—	—
5	2/19–2/28	Bermuda	1740	0.55	0.011	0.008	—
6	2/29–3/9	Bermuda	732	0.52	0.031	0.015	0.008
7	4/8–4/11	Bermuda	1300	0.61	0.030	0.027	0.011
8	4/11–4/17	Bermuda	860	0.21	0.022	0.010	0.012
9	6/4–6/5	33°20'N, 65°14'W	300	1.6	0.016	0.009	0.090
10	6/5–6/6	34°39'N, 66°15'W	267	0.79	0.015	0.016	0.066
11	6/7–6/8	37°39'N, 68°12'W	402	—	0.009	0.013	0.039
12	6/8	38°43'N, 69°14'W	222	0.72	0.010	0.015	0.055
13	6/9	40°32'N, 70°20'W	196	0.83	0.055	0.037	0.17
14	1/18–1/19	U.R.I.	392	4.0	—	—	—
15	1/21–1/22	U.R.I.	1071	2.1	—	—	—
16	2/4–2/5	U.R.I.	744	5.8	—	—	—
17	5/8	Providence, R.I.	76	9.4	0.090	0.025	0.25

* Samples 9 through 13 were collected from the R.V. *Trident* while the ship was en route. The location marks the midpoint of the collection track. † Calculated as Aroclor 1242 or Aroclor 1248. ‡ Both cis- and trans-chlordane.

T.F. Bidleman and C.E. Olney, Science 183, 316 (1974).

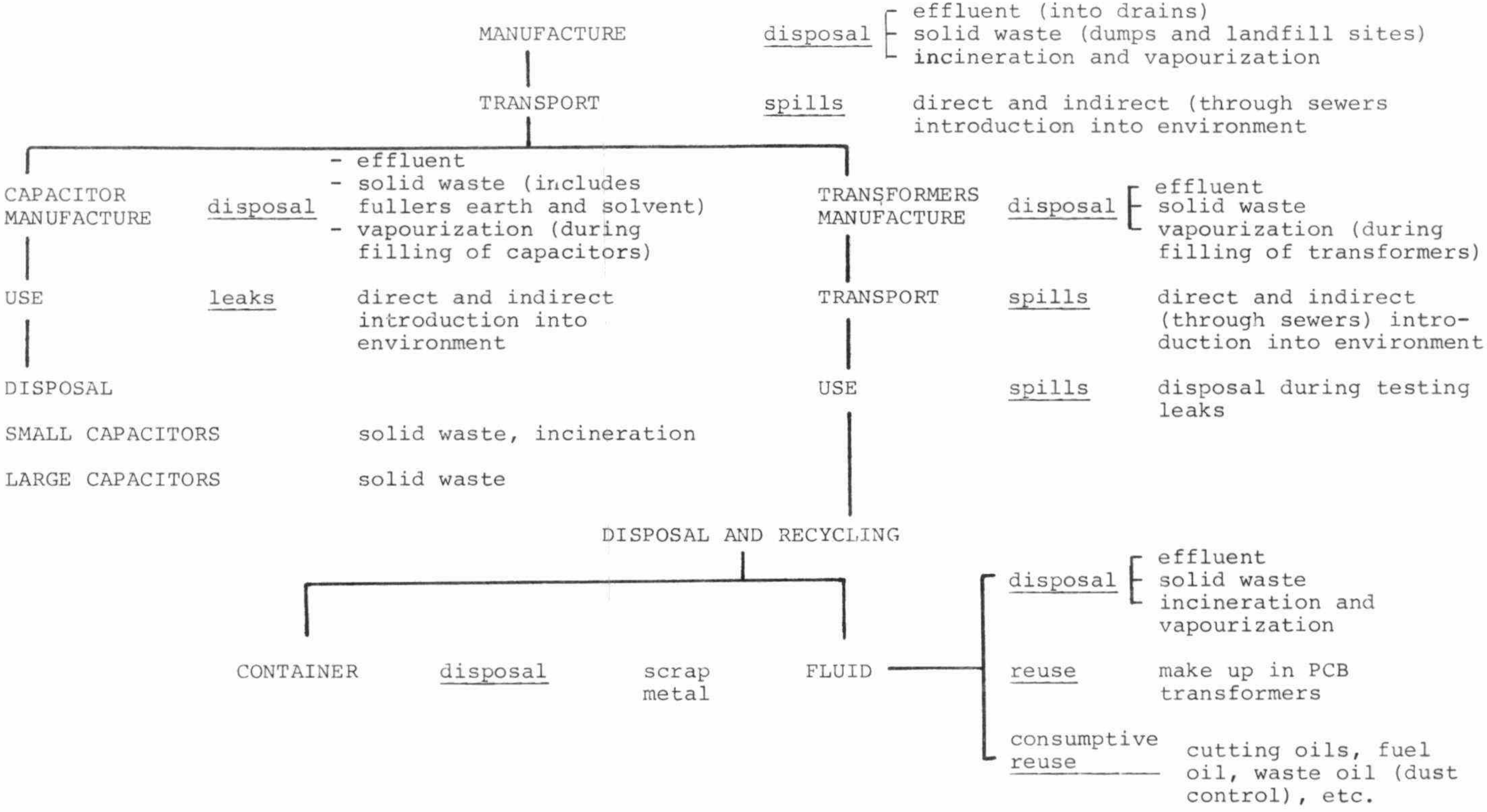
APPENDIX II

PCB DISCHARGES

Industrial Waste Discharges Direct to the Environment

The use of PCB as a dieletric and its possible entry into the environment has been represented on the following flow chart from manufacture to final disposal for capacitors and transformers.

Flow Chart of PCB from Manufacture to Disposal and Routes to the Environment


MANUFACTURE
disposal
effluent (into drains)
solid waste (dumps and landfill sites)
incineration and vapourization
TRANSPORT
spills
direct and indirect (through sewers introduction into environment
CAPACITOR MANUFACTURE
disposal
- effluent
- solid waste (includes fullers earth and solvent)
- vapourization (during filling of capacitors)
USE
leaks
direct and indirect introduction into environment
DISPOSAL
SMALL CAPACITORS
solid waste, incineration
LARGE CAPACITORS
solid waste
TRANSFORMERS MANUFACTURE
disposal
effluent
solid waste
vapourization (during filling of transformers)
TRANSPORT
spills
direct and indirect (through sewers) introduction into environment
USE
spills
disposal during testing leaks
DISPOSAL AND RECYCLING
CONTAINER
disposal
scrap metal
FLUID
disposal
effluent
solid waste
incineration and vapourization
reuse
make up in PCB transformers
consumptive reuse
cutting oils, fuel oil, waste oil (dust control), etc.

The manufacture of PCB may result in this substance entering the environment through drains, in solid waste and from vapourization. PCBs are not manufactured in Canada and thus this route of contamination probably does not occur. In the transportation of PCBs from the manufacturer to the capacitor and transformer manufacturer, spills may occur which will allow PCB to be released by seepage from the spill site.

Capacitor manufacturing may result in losses in liquid effluents through improper handling of PCB liquid, losses to the air from vapourization and venting of PCB tankage etc., and losses via the disposal of contaminated scrap and other solid waste. PCB losses may also occur during distribution or usage of the capacitor through damage, failure or leakage.

The manufacture of transformers may give rise to similar losses through all stages of manufacture, transport, usage and disposal.

The major routes into the environment of PCBs from transformers is probably from the disposal of scrap transformers and the disposal, usage or resale of the insulating oil.

The C.G.E. plant in Guelph is the only transformer or capacitor manufacturing plant in Ontario which had a discharge of PCB wastes directly to the environment. For a long period wastes containing PCBs were discharged to a marsh at the rear of the plant. The marsh continues to show evidence of contamination and a spill of non-PCB insulating oil in 1973 resulted in the solubilization of the PCB in the marsh sediments and subsequent release of PCB into the marsh drainage and hence into the Speed River. Subsequent action by the company has essentially isolated the PCB handling area from the plant sewer system and directed all other waste flows to the municipal sanitary sewers.

Other direct discharges that have been identified show no consistent pattern of source, mode of entry or type of PCB usage.

The B.P. Canada Limited refinery in Oakville formerly used PCB as a heat transfer fluid in the manufacture of asphalt. Since 1972 alternative non-PCB fluids have been used in this application due to restrictions on PCB sales imposed by Monsanto. However, recent analysis of this heat transfer fluid has indicated that it now contains 8% PCB. This suggests that 92% of the original PCB in the heat exchange system has been lost and replaced by the alternate fluid. Analysis of the effluent from the refinery and the refinery waste treatment plant sludge confirms the presence of PCB. The company has been requested to institute strict controls of losses of heat transfer fluid.

Similar situations may exist at former users of PCB as hydraulic fluids. Such applications usually involved a consumptive usage of fluid to account for losses. Consequently, sales of PCB to these users were curtailed by Monsanto in 1972.

Nevertheless, there is potential for continuing losses of the inventory of PCB fluid in these systems. The following plants were identified in 1970 as users of PCB in heat transfer and hydraulic fluid applications:

Midland Industries Ltd. - Midland	Heat transfer fluid
B.P. Canada Ltd. - Oakville	Heat transfer fluid
Budd Automotive - Kitchener	Hydraulic fluid
Crowe Foundry - Hespeler	Hydraulic fluid
Amerock Ltd - Meaford	Hydraulic fluid
General Motors - St. Catharines	Hydraulic fluid

Industrial abatement staff in the respective Ministry Regional Offices have been requested to investigate these sources.

Other potential direct industrial discharges are from the usage of PCB impregnated casting waxes, from imported sources of supply, by investment casting plants. This has been investigated in Ontario and to date there is no evidence of PCB impregnated waxes being used in Ontario plants.

Losses of insulating fluid from transformers and capacitors in use in industrial and public utility application is also a potential source of direct discharge. Indirect evidence, such as levels of PCB in sediments in the vicinity of major industrial centres, suggest that this has occurred but there is little recent direct evidence of such discharges. Procedures and policies have been instituted by Ontario Hydro to control PCB losses from transformers and capacitors. Failed and scrap equipment is stock-piled by Ontario Hydro for subsequent disposal to the Chemtrol landfill facility in Model City, New York. This service has also been provided by Ontario Hydro to local Public Utilities.

The control of discharges from industrial installation has been less well organized, although users have been advised by electrical equipment manufacturers and suppliers of the potential environmental hazard of PCBs. Sediment analysis in Lake Superior in the vicinity of Marathon, Ontario indicated a level of PCB of 1300 ppb, the highest level recorded in the Lake. This may be indicative of losses from the American Can of Canada Limited pulp mill although the distance from the location of the sediment to Marathon make this a remote possibility.

Indirect Discharges

Solid Waste Disposal Dumps

The leachate from seven landfill sites in Ontario was sampled in July, 1975, and analyzed by the Ministry of the Environment, Ontario. The results are shown in the Table below:

CONCENTRATION OF PCB IN LANDFILL LEACHATE IN ppb. 1975

Location	PCB in ppb
Violet	Not detected
Beare Road	0.04
Preston	0.02
Preston	0.02
Mississauga	1.2
Brantford	0.24
Paris	0.20

Waste PCB disposal into landfill sites and into solid waste disposal dumps was thought to represent the major route into the environment (Nelson, 1972). More than 50% of the PCB produced was estimated to be deposited in this manner. The small amount of PCB in groundwater from a landfill site indicates that landfill leachate is probably not a major source of PCB into the Great Lakes environment, however these data are not extensive and are only concerned with concentrations rather than quantities.

Municipal Sewage Effluents

PCB may enter municipal sewerage systems from industrial and commercial establishments using PCBs or equipment containing PCB. All municipal sewerage systems appear to show some evidence of contamination and there appears to be a background level of PCB discharge. This background level, in the absence of any identifiable direct inputs, may be the result of leaching and weathering of materials containing PCBs, it may be the result of PCB associated with particulate from street run-off and it may be from background concentrations in rainfall and surface waters. The following Table represents data on quantities of PCB entering and leaving selected Ontario sewage treatment plants.

ESTIMATED INFLUENT AND EFFLUENT PCBs LOADINGS FOR
WASTEWATER TREATMENT PLANTS IN SELECTED ONTARIO MUNICIPALITIES 1974.

LOCATION	LOADING (kg/yr)	
	Influent	Effluent
BURLINGTON	19.9	1.3
CHATHAM	3.3	0.7
ELMIRA	0.2	0.2
GRIMSBY	0.03	0.03
HAMILTON	154.1	25.8
KINGSTON CITY	5.9	3.9
KITCHENER	17.9	4.0
LONDON - GREENWAY	2.7	1.4
NEW HAMBURG	0.1	0.03
NEWMARKET	1.1	0.3
NIAGARA-ON-THE-LAKE	0.3	0.1
OAKVILLE	2.0	1.0
OSHAWA	1.0	1.0
OTTAWA - GREENS CREEK	32.3	10.7
PETERBOROUGH	14.9	1.5
PORT DOVER	0.6	0.2
SARNIA	3.5	2.3
TORONTO - MAIN	165.9	119.2
TORONTO - HUMBER	62.6	41.7
TORONTO HIGHLAND	3.1	3.1
TORONTO NORTH	1.5	1.5
WATERDOWN	0.02	0.02
WATERLOO	2.2	1.1
WELLAND	1.2	1.2
WINDSOR - WEST	67.5	35.8
WINDSOR - LITTLE RIVER	2.7	0.7
TOTAL	563.74	246.18

From Shannon etal.
EPS Report, 1975

High levels of PCB in sewage in Toronto, Peterborough and Hamilton are likely the result of past or present disposal practices at transformer and capacitor manufacturing plants in these municipalities. Other potential sources of direct discharge into sewerage systems may be disposal of quantities of PCB insulating oil removed from industrial and public utility transformers for routine checking, and the losses from industrial hydraulic and heat transfer systems containing PCBs.

Incineration

Inefficient combustion of liquid and solid wastes containing PCB will result in the vapourization of PCB into the atmosphere. Conventional, multiple hearth sewage sludge incinerators may be inadequate to destroy PCB residues in these sludges. This is under investigation.

There is no approved commercial incinerator in Ontario capable of destroying PCB liquid. The Chemtrol Disposal Services facility in Model City, New York, is the only incinerator close to Ontario which is available for this purpose.

The Thermal Degradation System incinerator in Hamilton has limited capability to burn chlorinated hydrocarbon but it lacks the necessary emission controls and is not approved for burning PCBs.

Experiments are being conducted on the utilization of waste PCB in cement kilns, (see section on air emissions) and hopefully this will offer a solution to the problem of disposal of PCB liquid.

Other Sources of Indirect Discharge

The usage of PCB in carbonless copying paper and in some printing inks has been identified as a potential source of PCB loss through the recycling and repulping of waste paper.

In 1972 the Abitibi Provincial Paper Mill in Thorold was sampled for PCB. The effluent from the deinking process was found to contain 600 ppb PCB. The quantity released in this manner is uncertain but in relation to the concentrations commonly found in municipal sewers (usually about 1 ppb) it must be regarded as significant.

APPENDIX III

MONITORING REQUIREMENTS

There are significant gaps in our knowledge of the nature and extent of PCB contamination in the Ontario environment. Future programs should be instituted to fill these gaps. Such programs should, however, be designed taking into consideration the available analytical capacity of the MOE Pesticide Laboratory.

The Pesticide Laboratory has been involved with PCB analysis since 1969. As well as carrying out routine PCB analyses on a wide range of substrate materials, the laboratory has developed and published several innovative contributions to PCB analytical methodology.

The following comprises an outline of present and potential capabilities for PCB monitoring analyses, existing and planned programs contributing to our routine workload, and existing and proposed projects for PCB analytical development and investigations.

1) Laboratory Capabilities for PCB Analysis

a) Fish. Major routine workload of the laboratory at present consists of fish samples from various Ministry of Natural Resources projects. Capability, using 5 staff, 2 fully automated Gas Chromatographs is approximately 18 samples/day for full PCB and organo-chlorine pesticide scan.

Capacity for fish analysis	18 per day
Workload on hand	150 days

b) Waters, Effluents and Sediment Samples

Using existing instrumentation, and three staff at present available for this work, output is limited to approximately 10 water or effluent samples, or approximately 6 sediment analyses per day, if analyzed for PCBs only. Automation of an existing chromatograph would permit increase in output to 20-30 water samples per day, operating the instrument on a 24 hour basis.

The above estimates of laboratory capacity using 8 staff for PCB and organochlorine pesticide analysis would occupy almost the total resources of the Pesticides laboratory (present staff level is 10). With present resources such an arrangement is practical only on an emergency basis for short periods only. Long term operation on this scale will require significant re-assignment of resources within the Organic Trace Contaminants Section, since the Pesticide Laboratory has other commitments to major Federal-Provincial cost-shared programs (IJC etc.). These require analytical capacity in other areas such as herbicides, organophosphate and carbamate insecticides, polynuclear aromatic hydrocarbons.

2) Program Involvement

The Pesticide Laboratory has samples on hand from, or has undertaken to provide analytical support for the following programs:

a) General Sampling - Sediments, Waters, Effluents

1976 Programs

Agency(s)	Program/Location	Sample type	# of samp.
IJC/MOE	PLUARG	Water Sediment	440 350
MOE	C.G.E. Guelph C.G.E. Peterborough Ferranti-Packard (St.Cath) Dowling PCB spill	Water Sediments Various biological samples	300-400 estimate

MOE/MNR	Bay of Quinte	Fish	150
MOE/MNR	St. Lawrence River	Fish	180
MOE/MNR	Sydenham River Nottawasaga River	Fish	150
MOE/MNR	Other	Fish	100

The following table of sampling sites, species and numbers of samples forms the basis of an agreement between MOE and Ministry of Natural Resources for the collection and analysis of approximately 2000 to 2500 fish during 1976:

1976 Fish Contaminant Sampling Program

Great Lakes	# of Fish
Ontario	150
Erie: Kingsville, Wheatley, Port Stanley, Nanticoke, Dunnville	750
St. Clair	200
Huron	200
Superior	100
	1400
Anadromous fish (rainbow)	
Ontario: Ganaraska, another site	
Erie: Big Creek	
Huron: Saugeen, Bayfield, Nottawasaga, North Channel	
Superior: Sault Ste. Marie, Michipicoten or Nipigon area, Thunder Bay	
30 fish per site	300
Inland Waters	
Southern Ontario	
Rideau Lakes area	150

Southern Ontario (continued)

Kawartha Lakes (Scugog, Pigeon, Rice, Sturgeon)	200
Simcoe	100
Muskoka Lakes	100
Thames River	100
Grand River	100

Northern Ontario

Abitibi	100
Timiskaming	100
Temagami	150
Nipissing	100

Western Ontario

Nipigon	150
"Kenora area"	200
	1550

500-1000 fish for regional requests

Fish samples:

Great Lakes	1400 fish
Inland Lakes	1550 fish
Anadromous fish	300 fish
Regional request	1000 fish

Suggested Areas for Further Study

In order of priority, the following is a list of study programs that should be undertaken to broaden the knowledge on the sources and fate of PCBs in the environment:

1. Industrial effluent monitoring. Programs in this area have to date been fragmentary;
2. Air monitoring, especially with respect to emissions from incinerators and other potential point sources. Also, air transport of PCBs via rainfall and particulate fall-out together with modes of entry of PCB and the fate of PCB in air should be investigated;
3. The evaluation of the effectiveness of municipal sewage treatment processes for the removal of PCBs through
    a) adsorption of PCB in sludge and the fate of PCB after disposal of the sludge,
    b) degradation of PCB by microorganisms and the selectivity of the process and the nature of metabolates,
    c) the assessment of methods to improve the removal efficiency of the treatment processes.
4. Landfill leachate monitoring. The study and monitoring of landfills should be undertaken in order to assess their significance as sources of PCB discharge;

5. Fate of PCB spills in soils

   This should be investigated with respect to the following:

   a) Adsorption of PCB on to soils with relation to soil type to assess the selectivity of soils;
   b) Mobilization of PCB from soils into ground water;
   c) Metabolism of selected PCB isomers by soils bacteria together with the identification of potential toxic hydroxy metabolates and their movement;
   d) The investigation of methods of impoundment and control of spills after they occur.

6. The fate of PCB in sediments should be investigated in order to assess:

   a) the adsorption of PCB on to sediments;
   b) the release of PCB into water from sediments;
   c) the metabolism of PCB by microorganisms and other benthal organisms in sediments and the study of toxic metabolates;
   d) the evaluation of the half-life of PCB in existing sediments.

7. Chlorodibenzofurans. The assessment of the significance of these contaminants in commercial PCBs through:

   a) the development of analytical methods;

b) the measurement in fresh PCBs;

c) the formation during usage of PCBs.

8. The automation of PCB analytical methods.

Air Resources Branch Monitoring and Investigation Program for PCBs During 1976-1977

Technology Development and Appraisal Section will have prime responsibility for PCBs. TDA plan the following activities for the remainder of fiscal year 1975-76.

1. Plan and co-ordinate PCB source testing program sponsored by Environmental Protection Service, Ontario Region. The tests will include:

a) Large power transformer and capacitor filling operations, of which there are 5 in Ontario, will be investigated as sources of PCB emissions. Tests will be carried out at one capacitor manufacturer in the Southwest Region, one capacitor manufacturer in the Central Region, and one transformer manufacturer in the West Central Region (totalling 18 source tests).

b) Municipal incinerators in Toronto - one for general refuse (Commissioner's Street) and one for sewage sludge (Ashbridge's Bay, comprising 10 source tests and 12 process samples.

2. New Technology Unit of TDA will continue their evaluation of existing manufacturing processes and of substitute materials and new process technology. Specifically, engineering and design evaluations and emission factor estimates will be completed for the five transformer capacitor manufacturers in Ontario by the middle of 1976. Evaluation of substitute fluids in electrical application will continue throughout 1976-77.

3. Establish a preliminary inventory of PCB users and quantities with the co-operation of Regional Operations and Pollution Control Branches. The object is to provide data to assess potential atmospheric emissions of PCB and to plan for TDA's proposed ambient air quality survey in FY 1976-77 (see below).

4. Development of a general purpose combined pre-filter solid adsorbent field sampler for PCBs in ambient air. The sampler will be useful for all organic vapours in the atmosphere. The Air Quality and Organic Trace Contaminants Laboratories have agreed to co-operate in the development and testing study, which will be completed in time to allow ambient air surveys during the summer as outlined below.

During the fiscal year 1976-77, the following program is planned:

1. Additional source testing based on the results of the initial tests described above. The object would be complete characterisation of certain sources: mass balances, multi-media assessment, etc. The project would run throughout 1976-77. Additional sites for testing will include three in Hamilton; namely, the municipal incinerator and its associated pilot plant, and the SWARU incinerator;
2. A six-month ambient air quality survey to be completed by December, 1976 or January, 1977 in:
    a) Urban areas - Windsor (trans-boundary transport of PCB from U.S. incineration and industrial activity), Hamilton and Toronto (heavy industrial use, incineration), Ottawa (little industrial use, "background"), and one or two other cities to be selected.

    b) Ambient air survey of Ontario Hydro and local PUC large transformer and capacitor installations for airborne PCB. June-September, 1976.
3. Air Resources Branch Research Grants Program:
    a) Study of persistence and atmospheric chemical lifetime of commercial PCB mixtures and pure isomers, photochemical degradation products (if any), reactivity towards NO_x, OH, O_3, etc.

   b) Precipitation scavenging of airborne PCB (particulate and vapour); rain and snow events. Snow samples be collected during the winter season and the melt water stored for analysis;

4. Baseline studies of airborne PCBs by Instrumentation Development and Monitoring Unit's mobile van in Northern Ontario (remote) during the summer of 1976.

5. As follow up to the St. Lawrence Cement project, ARB should pursue a study of the feasibility of routinely disposing of waste PCBs by incineration in cement kilns. This would involve additional chemical analyses to characterise waste oils and solvents and a study of methods of collecting and delivering PCBs to St. Lawrence Cement or other appropriate cement kiln facilities.

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